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LOW COST SOLAR ARRAY PROJECT
Production Process and Equipment Task

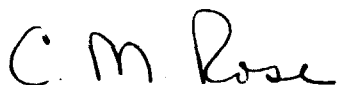
A MODULE EXPERIMENTAL PROCESS SYSTEM DEVELOPMENT UNIT (MEPSDU)

QUARTERLY REPORT NO. 1
November 26, 1980 to February 28, 1981

Contract No. 955909

The JPL Low-Cost Silicon Array Project is sponsored by the U. S. Department of Energy and forms part of the Solar Photovoltaic Conversion Program to initiate a major effort toward the development of low-cost solar arrays. This work was performed for the Jet Propulsion Laboratory, California Institute of Technology, by agreement between NASA and DOE.

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1. CONTRACT GOALS AND OBJECTIVES

The objective of this contract is to demonstrate technical readiness for the production of photovoltaic modules using single crystal silicon dendritic web sheet material. This demonstration of technical readiness will be accomplished by:

- (1) The selection, design, and implementation of a solar cell and photovoltaic module process sequence in a Module Experimental Process System Development Unit (MEPSDU).
- (2) Demonstration runs of the MEPSDU in which 240 modules will be produced.
- (3) Passing of acceptance and qualification tests by modules produced during the demonstration runs.
- (4) Achievement of a 1986 module FOB price of 70¢ or less per watt peak in 1980 dollars as calculated by SAMIS.

2. SUMMARY

Work on the Westinghouse MEPSDU contract was initiated on November 26, 1980. This report describes work performed during the first three month period of the contract (November 26, 1980 through February 28, 1981) and outlines plans for the second quarter.

Technical work during the first quarter of the program was directed toward completing all design and documentation tasks associated with the MEPSDU Preliminary Design Review Data Package submittal. Highlights of this effort consisted of:

- Preparation of a Preliminary Specification for MEPSDU Input Sheet Material (Dendritic Web Silicon)
- Preparation of a MEPSDU Module Preliminary Design Layout Drawing and all associated detail drawings
- Analysis of the performance of the MEPSDU module over a range of operating conditions
- Definition of all steps in the Baseline Process Sequence
- Initiation of Equipment Specifications for all long lead time items in the MEPSDU
- Initiation of preliminary design work on the cassette unload element and interconnect feed element of the Automated Cell Interconnect Station
- Preparation of the Preliminary Quality Assurance Plan

3. TECHNICAL PROGRESS

A. Selection of Input Sheet Material

To ensure minimum cost of photovoltaic cells, there are two essential requirements for the starting material: high quality, i.e., capable of producing high efficiency cells, and effective material utilization. Single crystal, dendritic web silicon satisfies both these requirements and has been selected as the Westinghouse MEPSDU input sheet material.

Figure 1 shows a length of dendritic web silicon in the as-grown condition being removed from the growth furnace. The shape of the dendritic web is determined by a combination of crystallographic and surface tension forces as it is formed from the molten silicon. The absence of any die material precludes contamination and die material inclusions which are known problems with other ribbon growth techniques. Cells fabricated on dendritic web have shown efficiencies comparable to cells fabricated on Czochralski wafers. The process conserves expensive silicon since the as-grown material is thin - 110 to 170 μm , and the smooth surface does not require extensive treatment prior to cell fabrication.

The natural rectangular shape of cells fabricated on dendritic web permits high module packing factors which contributes to high module efficiency.

Investigations in the production and application of photovoltaic modules have confirmed that high module efficiency has many benefits ranging from decreased module encapsulation costs to significant balance of system and installation cost savings. In the area of module fabrication alone, a cost saving of six cents per watt is associated with each 1% increase in module efficiency. High quality starting material is essential to producing high efficiency cells and modules. Dendritic web is high quality, single crystal silicon, and has already been used in fabricating photovoltaic cells with efficiencies greater than 15% and modules with efficiencies greater than 12%.

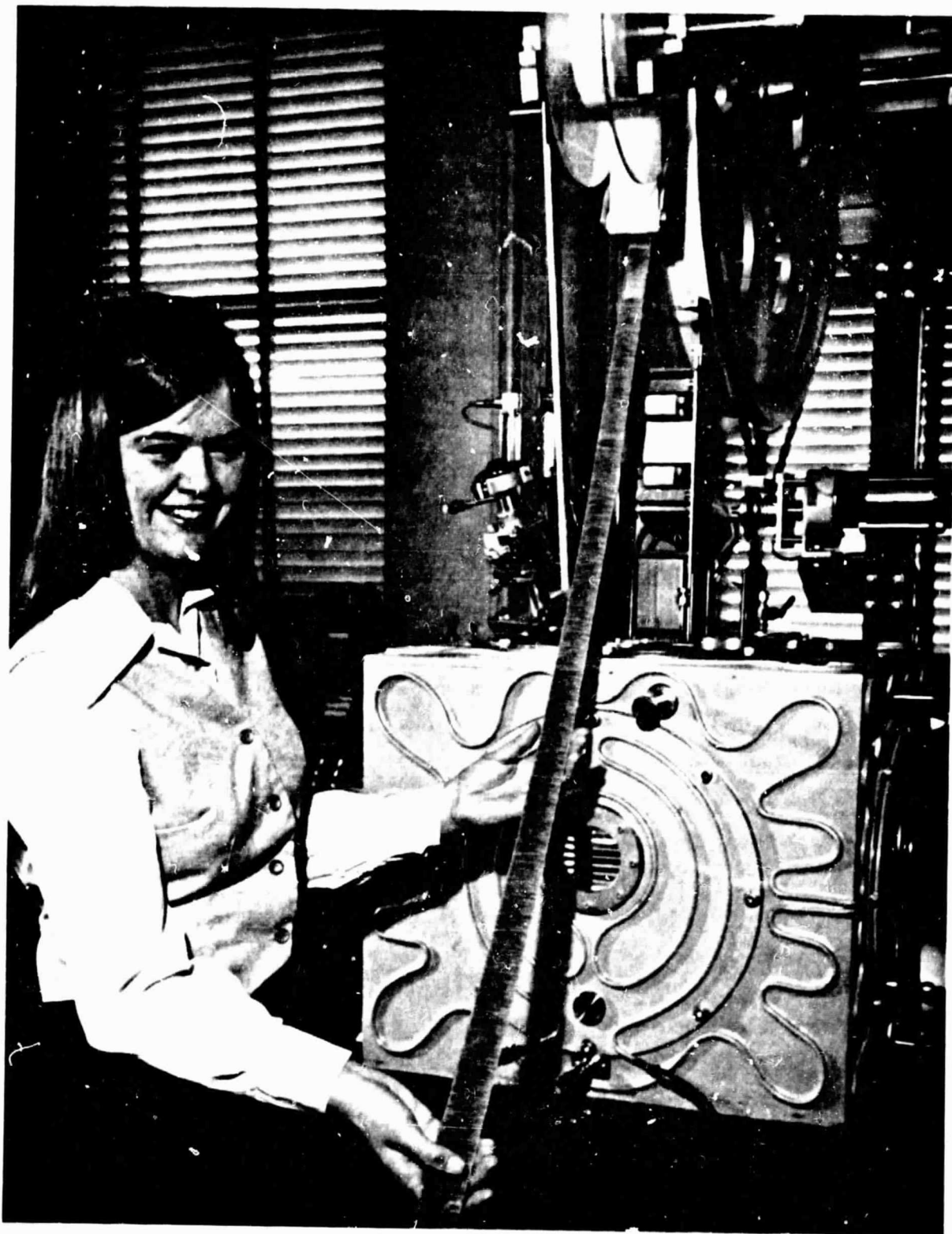


Figure 1. Westinghouse Dendritic Web being Removed from the Dendritic Web Growth Furnace

A preliminary material specification for the polycrystalline silicon used as a feed stock in the dendritic web furnaces has been prepared and is shown in Table 1. Table 2 shows the preliminary material specifications for the dendritic web silicon sheet input.

B. Module Design and Analysis

During the first quarter of the Westinghouse MEPSDU program, a preliminary design of the MEPSDU module has been prepared (Westinghouse Drawing 712J916) and submitted to JPL. This drawing is included in this report as Figure 2. The module contains 180 cells arranged in four parallel sets of 45 cells connected in series. The maximum overall dimensions of the module are 1200 mm x 397 mm, which comply with the requirements of the 1982 Technical Readiness Module Design and Test Specification, 5101-138. Realistic tolerances will be assigned to components as they are detailed, and realistic clearances between components will be provided. These tolerances and clearances will be based upon experience with the Westinghouse Pre-Pilot Line modules which are presently being assembled. For example, the clearance between cells has been reduced from 1.5 mm, which was tentatively selected, to 1.0 mm (and the module packing density correspondingly increased) because the ultrasonic bonding equipment used to join cells has already demonstrated its capability to operate with this reduced clearance.

The photovoltaic cells on which this module design is based are 90.8 mm x 25 mm. Forty-five of these cells in series will produce an open-circuit voltage of about 24.7 volts, which will be somewhat reduced under operating conditions.

The Preliminary Design module incorporates a Cor-Ten "A" steel frame. However, an alternative frame design is being explored. This alternative design is made of glass fiber reinforced polyester "pultrusions," a material developed by Westinghouse Insulating Materials Division approximately ten years ago for outdoor electrical insulation and currently widely used. The advantages expected from this change in material are lower cost, reduced weight, better appearance, and complete elimination of module grounding considerations.

TABLE 1

POLYCRYSTALLINE SILICON SPECIFICATION

- Boule to be 5-10 cm in diameter
- Random lengths acceptable, but length must be in excess of 15 cm
- Less than 0.3 PPBA boron concentration
- Less than 0.5 PPBA phosphorous concentration
- Less than 10 PPBA aluminum concentration
- All other metals less than 5 PPBA concentration

TABLE 2

MFPSDU DENDRITIC WEB INPUT SHEET MATERIAL SPECIFICATION
(PRELIMINARY)

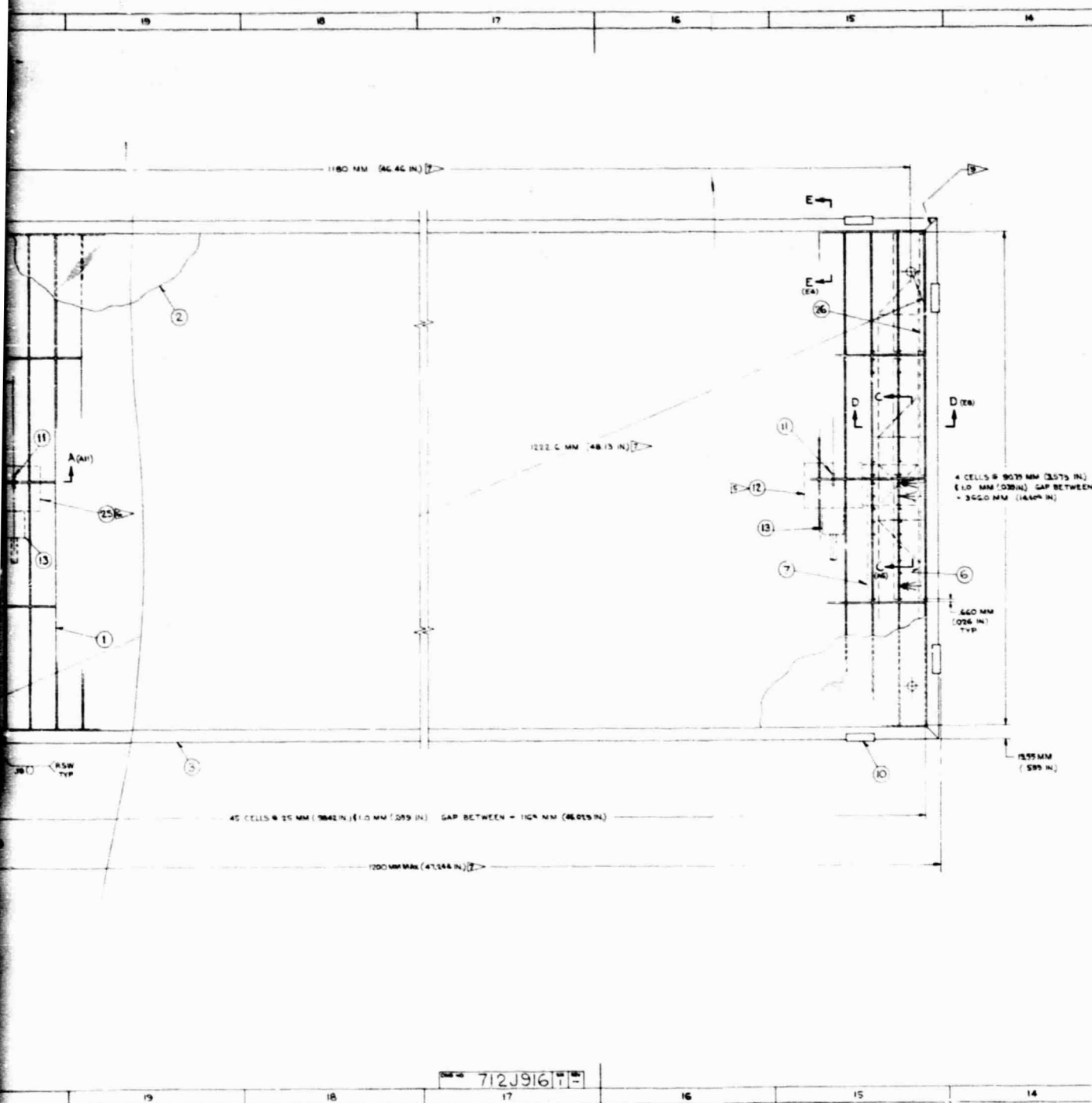
I. Chemical

- A. Single crystal silicon with 111 web surface orientation.
- B. P-type material with boron based dopant providing a resistivity in the range 3 to 12 ohm cm.

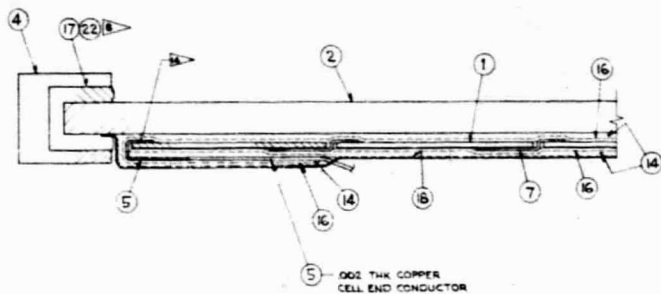
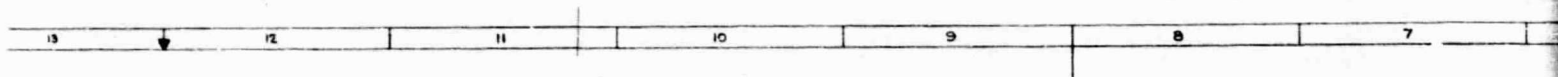
II. Physical

- A. Thickness of web: $140 \pm 30 \mu\text{m}$
- B. Width of web: Equal to or greater than 2.55 cm excluding dendrites
- C. Length* of web: $43 \pm .5 \text{ cm}$
- D. Surface striations across web not to exceed $1 \mu\text{m}$ height as measured by a thickness monitor such as "Taly-Step" or "Data-Trak."
- E. Etch pit density (determined after 5 min. Sirtl etch) not to exceed $3 \times 10^4/\text{cm}^2$
- F. Flatness: No twist or bow as determined by visual inspection.

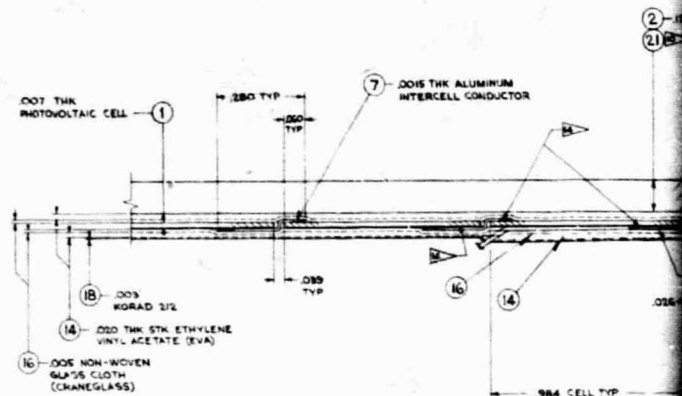
*Shorter lengths are acceptable but will produce less than 4 cells/strip, thus reducing yield of all cell processing operations.



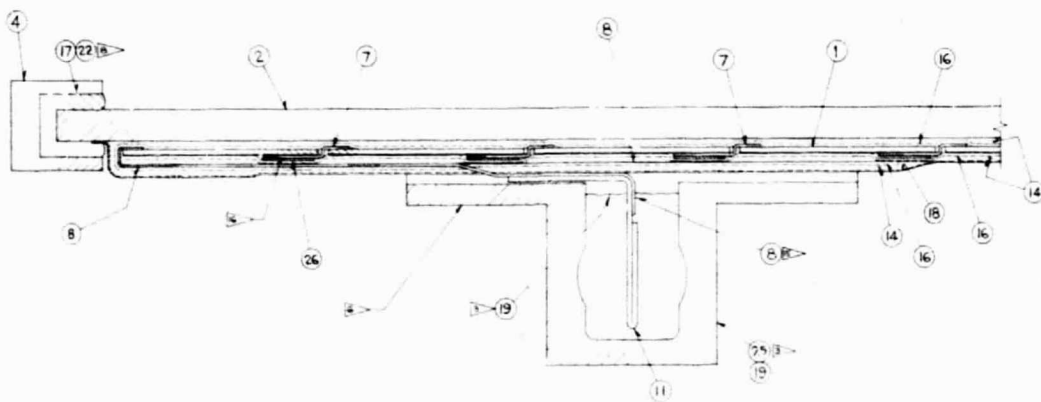
FOLDOUT FRAME 2



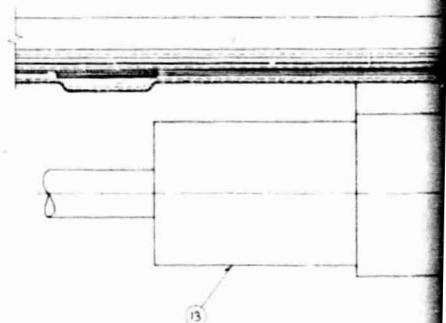
SECTION B-B (E20)



SECTION D-D (F15)



SECTION A-A (E20)



712J916

FOLDOUT FRAME



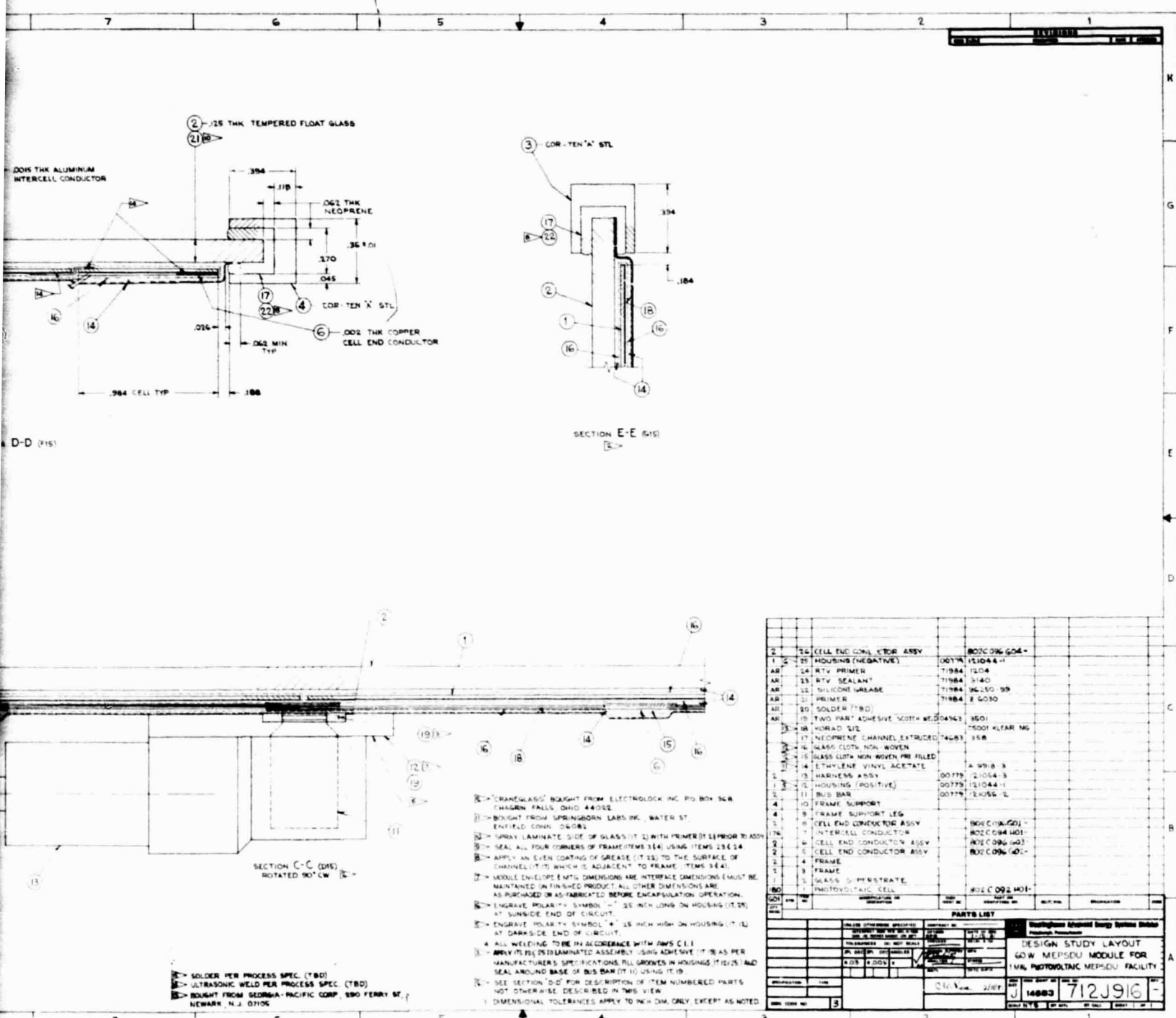


Figure 2. Westinghouse MEPSDU Module,
Preliminary Layout Drawing

A mechanical mock-up of the MEPSDU module (frame and lamination layup with superstrate and length of web in place of the solar cells) was fabricated in February and has survived the out-of-plane mounting surface test specified in JPL Document 5101-138 without damage. In addition, a similar mock-up incorporating a glass fiber reinforced polyester pultruded frame was also fabricated and has survived the same test. A pull test on the electrical connection harness normal to the module back face, i.e., tending to peel off the connector housing, demonstrated that the weight of the module can be comfortably supported by one electrical connection. In a separate test using a simulated superstrate (non-tempered window glass), the glass shattered with a normal load of 140 pounds.

In addition to the layout drawing, an interface drawing and detail drawings of the photovoltaic cell, intercell conductor and transverse conductors were completed. This module design, including a complete description of its assembly processes, will be presented at the MEPSDU Preliminary Design Review Meeting.

A preliminary materials selection sheet specifying all materials incorporated in the MEPSDU module design has been prepared and submitted to JPL as part of the Preliminary Design Review Data Package.

One of the items specified on the materials selection sheet is a Korad-® KLEAR back cover moisture barrier. It was reported at the last Project Integration Meeting (17th PIM) that Korad-® KLEAR may not be an acceptable backing material for the laminated module due to its inherent low weatherability. Accordingly, data and samples of two alternate materials are now being obtained: Tedlar® (a polyvinyl fluoride) and X-22417 (an oriented acrylic). These materials will be studied as possible substitutes for Korad-® KLEAR.

An experiment has been conducted to determine the nominal operating cell temperature (NOCT) of the MEPSDU module. A small (5" by 8") encapsulated module having the layup configuration specified on the MEPSDU module layout drawing was fabricated and instrumented for this experiment. Results of the experiment indicated that at 80 mW/cm^2 insolation and in 25°C still air, the thermal impedance of

the encapsulation (including air boundary layer) was $300^{\circ}\text{C}/\text{cm}^2/\text{watt}$. The data showed a 24°C air-to-cell temperature rise.

A preliminary performance analysis of the MEPSDU module has been completed. Table 3 lists input conditions and assumptions. Figure 3 shows the calculated performance parameters for insolation level of $80 \text{ mW}/\text{cm}^2$ plotted as a function of ambient temperature. This analysis will be updated as the module detail design is finalized.

C. Process Sequence Design

A preliminary process sequence has been defined for the fabrication of solar panels from dendritic web silicon. This sequence is described below.

- (1) Pre-diffusion Cleaning - This consists of a hydrofluoric acid dip, rinse, dry sequence followed by a CF_4/O_2 plasma etch.
- (2) Front and Back Surface Junction Formation and Oxide Etch - The back surface junction is formed first by applying an SiO_2 layer to the sun side of cleaned web, removing splatter traces of SiO_2 from the back surface with a hydrofluoric acid dip/rinse/dry sequence, diffusing boron into the clean silicon surface, and then removing the boron glass in a hydrofluoric acid dip/rinse/dry sequence. This process is repeated for the front surface where the junction is formed by phosphorous diffusion.
- (3) Antireflective (AR) and Photoresist (PR) Coating Application - The AR coating is applied first by controlled rate withdrawal from an organometallic solution to give a liquid film that is converted to $\text{TiO}_2/\text{SiO}_2$ after baking. The PR coating is applied, and its thickness is controlled in a similar manner.
- (4) Grid Pattern Definition - Standard photolithographic techniques of masking, exposing, developing, and pattern etching are employed.

TABLE 3

MEPSDU MODULE PERFORMANCE ANALYSIS: INPUT PARAMETERS AND ASSUMPTIONS

CELL:

SIZE: 2.5 x 9.08 x 0.015 cm

PERFORMANCE: AM1, 91.6 mW, 28°C

 $J_{sc} = 0.033 \text{ A}$ $V_{oc} = 0.580 \text{ V}$ $E_{ff} = 15\%$

ENCAPSULATION:

	CM	IN.
TEMPERED FLOAT GLASS	0.318	0.125
EVA	0.050	0.020
CRANEGLAS	0.013	0.005
CELL	0.015	0.006
CRANEGLAS	0.013	0.005
EVA	0.050	0.020
KORAD/MYLAR	0.007	0.003

MODULE:

SIZE OVER-ALL: 39.7 x 120 cm (15.6 in. x 47.2 in.)

INTER-CONNECT ARRANGEMENT: SERIES STRING OF 45 ELEMENTS
CONSISTING OF 4 STRINGS IN PARALLEL

CELL PACKING FACTOR 0.857

OPTICAL TRANSMISSION FACTOR 0.930

MISMATCH FACTOR 0.975

THERMAL IMPEDANCE (STILL AIR) $\sim 300^\circ \text{C}/\text{cm}^2/\text{WATT}$

NOCT

44°C

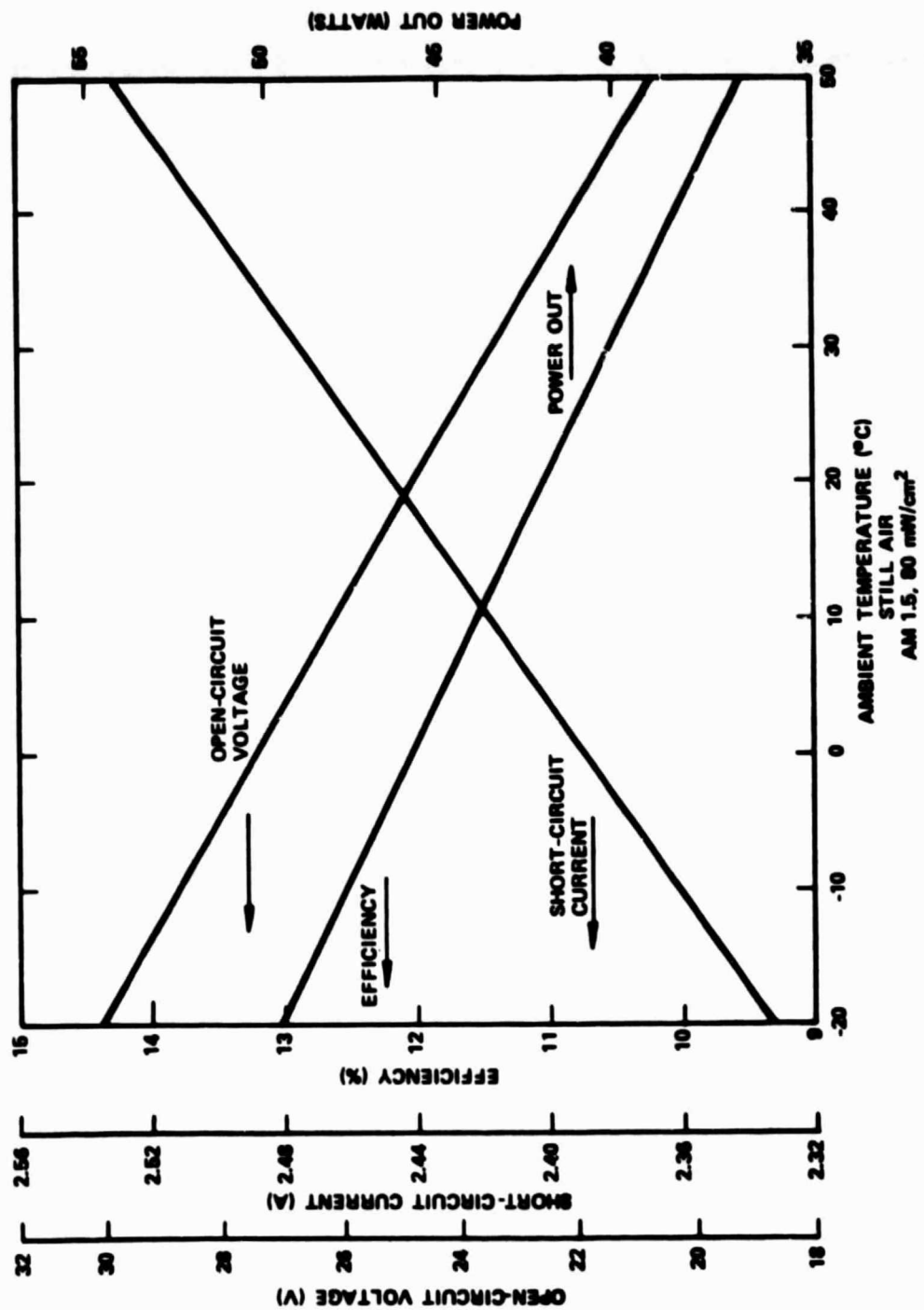


Figure 3. Predicted MEPSDU Module Performance (Preliminary)

- (5) Metallization - Successive layers of Ti, Pd, and Cu are deposited on the web by vacuum deposition.
- (6) Metal Rejection and Plating - Excess metal and photoresist are removed by ultrasonic dissolution of the PR in acetone. Residual PR is removed by plasma stripping. Copper is electroplated over the vacuum deposited metal film.
- (7) Cell Separation - Four cells are separated from the 42 cm web strip using a laser scribe followed by a mechanical breakout.
- (8) Cell Test - The I-V characteristic of each cell is measured at AM1, 100 mW/cm² and 28°C.
- (9) Cell Interconnection - Strings of 45 cells are joined in series with aluminum interconnects by ultrasonic bonding.
- (10) Module Lamination - Modules are built using a lay-up process of glass and polymeric materials, laminated, and incorporated into a framed structure.
- (11) Module Test - The I-V characteristic of each module is measured at AM1, 100 mW/cm² and 28°C cell temperature.
- (12) Module Package - Acceptable modules are crated for shipping.

This preliminary process sequence is outlined in the flow chart shown in Figure 4. Subdividing this process sequence into smaller component operations will aid the analysis and provide the most accurate SAMICS cost data possible.

The above preliminary process sequence will be modified as on-going investigations improve techniques in selected areas and demonstrate the potential for reduced processing costs. Two examples of potential alternatives that are being studied are: substitution of NiCu metallization prepared by plating techniques to replace vacuum evaporation of TiPdCu; and ion implantation of front and back junctions to replace the diffusion/cleaning steps.

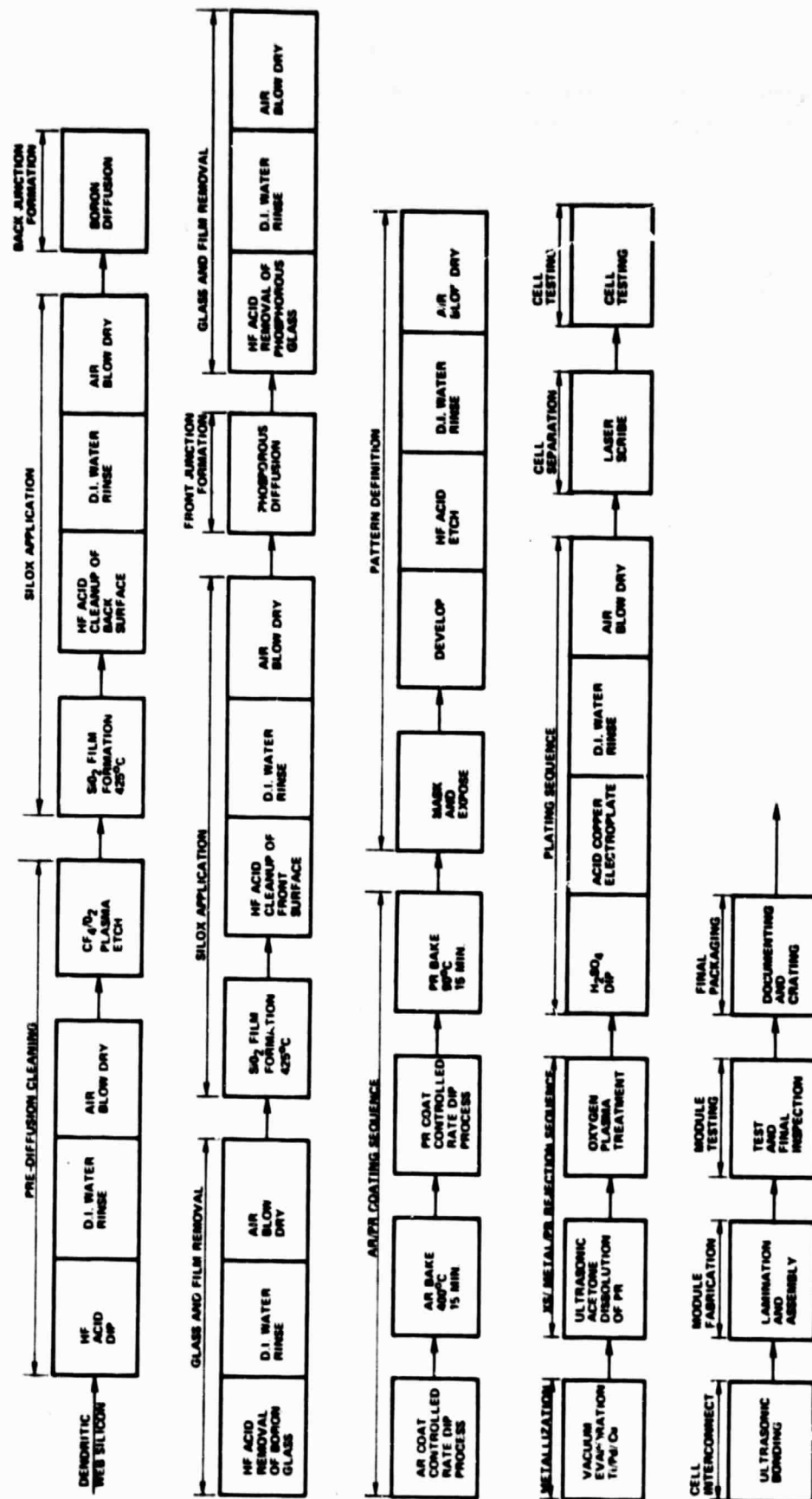


Figure 4. MEPSDU Preliminary Process Sequence Flow Chart

An expanded manufacturing flow chart of the module assembly operations has been prepared and is shown in Figure 5. It outlines the following operations:

- (1) Superstrate Preparation - Sized, low iron tempered float glass is cleaned with a commercial glass cleaner. The inner surface is primed with a dilute silane solution and dried with warm air. The superstrate is then placed in the transfer section of the cell tabbing and stringing machine.
- (2) Layup of Spacer and Pottant - A spacer of Craneglas is placed on the primed glass surface. Ethylene vinyl acetate (EVA) as a lamination pottant is placed on the Craneglas.
- (3) String Transfer - Bonded strings of 45 cells each are transferred from the bonding section of the cell tabbing and stringing machine and positioned on the EVA. Four 45 cell strings make up the 16 x 48 in. module array.
- (4) Addition of End Conductors - The bonder adds copper foil end conductors to each end of each of the four strings.
- (5) Transfer to Laminator - The module subassembly (sun side down) is moved to the vacuum laminator.
- (6) Preparation of End Conductors - Three rows of cells on each end of the strings are covered with a layer of EVA impregnated Craneglas to insulate the cells from the end conductors as they are folded back and together to form a common electrical leadout. During folding of the end conductors, EVA is interleaved between the copper foil to provide a moisture seal between the copper strips where they penetrate the lamination.
- (7) Layup of Back Spacer, Pottant, and Cover - A spacer of Craneglas is placed over the cell strings, EVA is placed over the Craneglas, and a back cover film of Korad[®] is placed on the EVA. The copper end conductors are brought through each of these insulating films as they are placed in position.

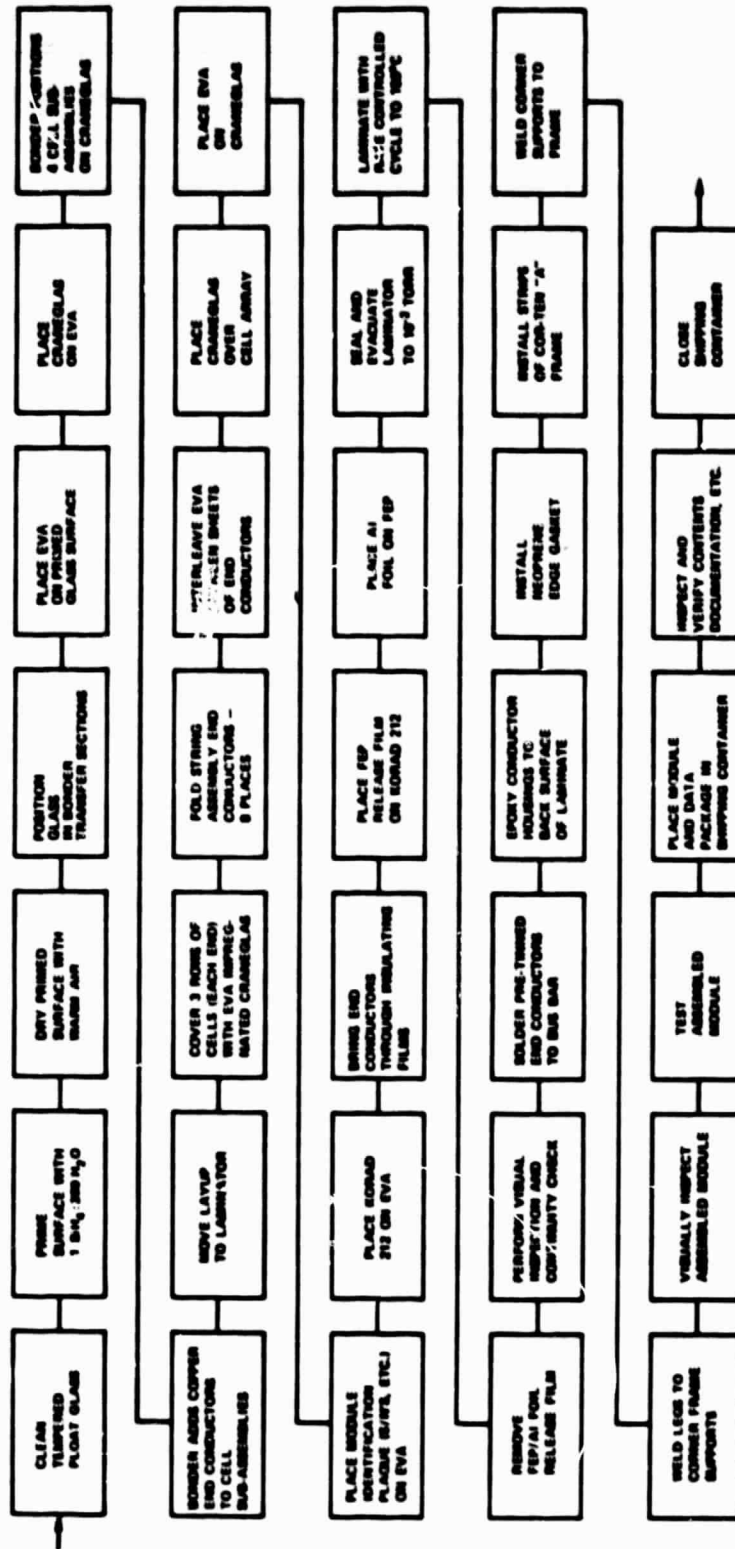


Figure 5. Module Assembly Flow Chart

- (8) Lamination - In preparation for lamination, release films of aluminum foil and fluorinated ethylene propylene copolymer (FEP) are placed over the module layup. The laminator is sealed and evacuated to 10^{-2} torr. It is heated to 110°C in less than 30 min., vented, heated to a maximum temperature of 150°C , and then cooled to room temperature. The FEP/Al foil release films are removed, and a visual inspection and electrical continuity check performed.
- (9) Complete Electrical Connections - The pre-tinned end conductors are soldered to a bus bar. The bus bar is enclosed by a conductor housing that is attached to the back surface of the laminate using an epoxy adhesive formulated for this service.
- (10) Frame Module - A neoprene gasket is installed around the edge of the module. Cor-Ten "A" frame strips are placed over the gasket, corner supports are welded to the frame, and legs are welded to the corner frame supports.
- (11) Inspect and Test - A visual inspection of the assembled module is performed, and the current-voltage characteristics of each module is measured at AM1, 100 mW/cm^2 and 28°C .
- (12) Module Packaging - Acceptable modules are crated for shipping. Each shipping container holds ten modules and their respective data packages. The contents of each shipping container are verified, and the container is closed.

D. MEPSDU Design

The process sequence defined for the Westinghouse MEPSDU was discussed in the previous section, and the type of equipment required for carrying out this sequence has been identified. Preparation of specifications for MEPSDU equipment is currently underway.

In the required MEPSDU equipment, there are several long lead items which must be ordered early in the program to meet the program schedule. These items are:

- Diffusion Furnace and Doping System
- Metallization System
- Plating System
- Laser Scribe for Cell Separation
- Cell Interconnect Station

In the first quarter of this program, a number of vendor conferences were held to help develop Equipment Specifications (E-Specs). Equipment Specifications were then prepared which included the following:

- (1) Throughput of web required ($200 \text{ cm}^2/\text{minute}$)
- (2) Process requirements
- (3) Control requirements
- (4) Reproducibility requirements
- (5) Operation and maintenance manuals requirements
- (6) Preventative maintenance schedule
- (7) Recommended spare parts inventory
- (8) Installation and training

These specifications have now been prepared for the diffusion furnace system, metallization system, and the laser scribe. Firm quotations of price and delivery are expected by late March, 1981.

In addition, numerous discussions have been held with vendors concerning the automation of several processing stations [(1) raw web cleaning, and (2) anti-reflection deposition and bake and photoresist deposition and bake]. The automation of these steps would further reduce the manual handling of the web which is now included in these process steps.

E. Automated Cell Interconnect Station

(1) Introduction

The Westinghouse MEPSDU has been designed using automated processing stations to the maximum extent feasible for a line of its size. Material transfers, for the most part, are manual. Automation of these transfers involves straightforward insertion, retrieval, or translations of cells or cell holding fixtures. The Westinghouse dendritic web cells are easily manipulated during operations performed prior to dendrite removal because the dendrities provide additional strength and ideal gripping surfaces.

The most difficult cell handling operations are those performed after the cell separation operation in which the dendrites are removed. The Westinghouse MEPSDU will demonstrate suitability for automated handling equipment for the dendritic web cells by totally automating the cell interconnect operation. Equipment and processes for the material transfer portion of this station are representative of those required in other stations.

Westinghouse has designated Kulicke and Soffa Industries, Inc., as its subcontractor for the design and development of MEPSDU equipment dealing with the automation of interconnection and assembly of its dendritic web silicon solar cells into module arrays. This subcontract deals with design, development, testing, and operation of equipment, and preparation of instruction manuals for the automated interconnect station.

The solar cell electrical interconnect configuration to be utilized by the interconnect station will be thin (.001 to .002") aluminum tabs connecting metallized pads located on the front surfaces of each cell with the metallized rear surface of the adjacent cell. The technology to be used to join aluminum tabs to metallized cell surfaces will be ultrasonic bonding. However, to minimize technical risk, the equipment developed for this application will be convertible to solder reflow bond technology.

(2) Machine Concepts

During this first quarter, the Kulicke and Soffa design effort concentrated on machine concepts to handle the Westinghouse solar cells and various concepts for the interconnection configuration. Sample cells were delivered to K&S by Westinghouse for study purposes.

Many factors entered into the design considerations. The sample cells revealed that gentle handling will be required to avoid damaging the cells. It was reasoned that a "walking beam" could attach to either side of a cell with rubber suction cups with minimum possibility of damage.

Another approach, a rotary table, was considered and set aside because of difficulties perceived in placing the cells on the table and then removing the cells from the table. These basic considerations led to the design approach that was selected.

(3) Interconnect Bonding Techniques

The candidate interconnect bond technique to be utilized is ultrasonic bonding since it is consistent with and compatible to the metallization system of the Westinghouse cell. It also represents a clean, fluxless technique which can enhance the cost effectiveness of the Westinghouse cell and metallization system.

Rotary seam bonding is the ultrasonic technique being considered for the proposed machine (see Figure 6). Westinghouse has previous experience in this technique and is privately funding an investigation by K&S into optimizing this technique for high production usage. Another ultrasonic bonding technique being studied is spot bonding with both fixed and rolling tooling. These systems may require multiple tool systems to achieve the desired machine cycle rate.

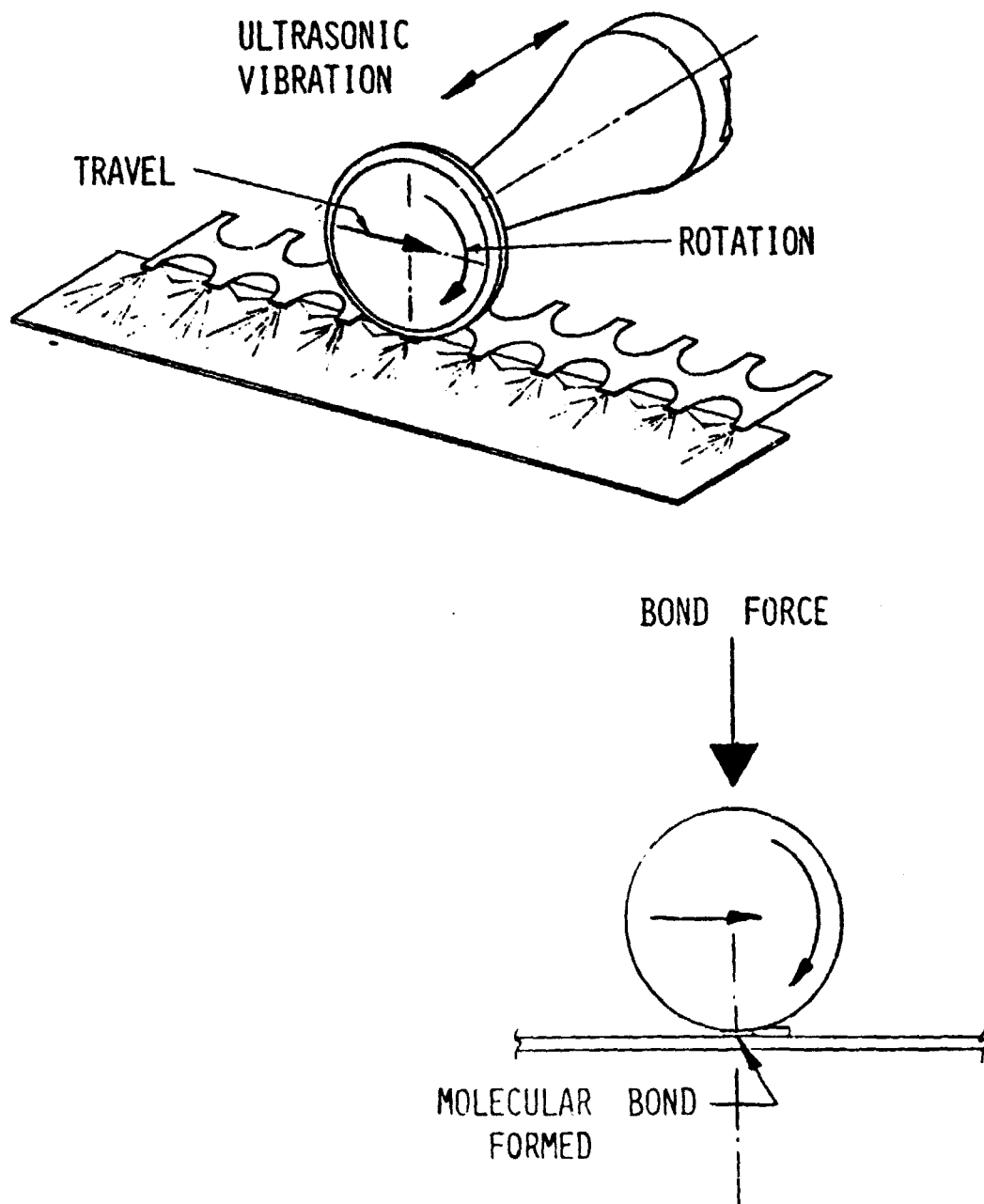


Figure 6. Rotary Ultrasonic Seam Bonding

The rotary seam welder being utilized for the investigative program by K&S is a Sonobond Model MS-5010 modified for this application by the manufacturer, Sonobond Corporation of West Chester, Pennsylvania. While the bonds achieved in this program are strong (average vertical pull strength of over 100 grams), the system has not yet demonstrated adequate speed in making bonds to meet the throughput rates of the MEPSDU Program.

Ultrasonic seam bonding will be deemed a viable method when reliability is proven on a continuous basis as determined by consistent quality of bonds, high yields, and demonstrate that target bond cycle times can be met to achieve the desired throughput rate. Further testing and large number of bonds must be made to make this determination.

In the interest of minimizing technical risk, pulsed heat solder reflow will be considered as the back-up interconnect technique. If this technique is used, the interconnect will be made from pre-tinned copper; and the machine will contain flux application stations prior to each pulse bond station and appropriate flux clean-up equipment.

(4) Interconnect Configuration

The proposed interconnect configuration is .0015 inch thick 1145 aluminum with prepunched round holes for minimum stamping cost (see Figure 7). The prepunched interconnect material will be stored and brought to the machine on large reels to minimize the need for loading and unloading them from the machine.

(5) Proposed Machine Design

K&S is to design, build, and deliver a tabbing and stringing machine which will assemble 2.5 x 9.08 cm rectangular solar cells into series strings of 45 or fewer cells (approximately 4' long strings) with the strings to be placed in final module format of four (4) strings wide (approximately 16" x 48"). The target machine cycle time is five seconds/cell with a yield of 95% or better.

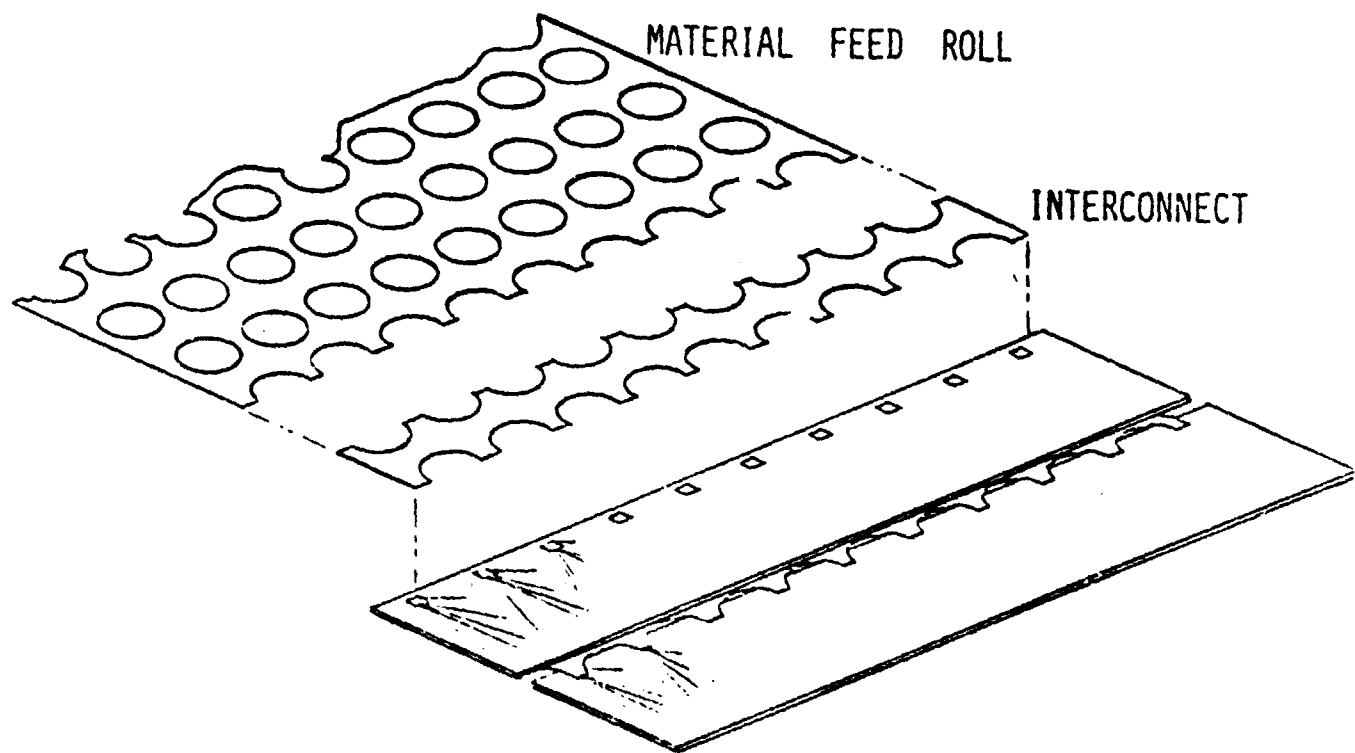


Figure 7. Proposed Interconnect Configuration

Figure 8 shows a flow diagram for the proposed machine. The machine to be developed and built (see Figures 9 and 10) will have a station where cells are automatically dispensed from cassettes to an alignment station. A walking beam conveyor picks up the cell and indexes it to the first bond station. In this bond station the foil interconnect will be fed from a pre-punched continuous roll of aluminum foil, sheared and transferred into position over the cell, and bonded to the cell by an ultrasonic rotary seam bonder system.

The walking beam conveyor then indexes the cell to an inverter system which inverts the cell and places it on the string conveyor in position to be bonded to the back of the previous cell by a rotary ultrasonic bonder while the cell is still being held by the inverter. The string conveyor then indexes the cells as they are joined together into strings approximately four (4) feet in length.

When each string is completed, it is automatically picked up using a track-mounted vacuum lance and moved to a test station where the string will be tested prior to being placed in the module array area in its desired format. The vacuum lance maintains the intercell mechanical spacing, and a track will be provided with detents to locate the strings for correct interstring spacing. A reject station is provided in the discharge area in case it is determined that the cell string should not be delivered to the module array area.

F. Economic Analysis

To establish the capability for performing detailed economic analyses, a computer terminal, including a CRT and Modem, has been leased and will be used exclusively for MEPSDU cost analysis (SAMICS). During February, an engineer and a technician attended an introductory terminal usage seminar given by the computer leasing service personnel in Pittsburgh.

Currently, activity in this area is limited to practice and familiarization exercises. Actual SAMICS calculations will be initiated when this familiarization task has been completed.

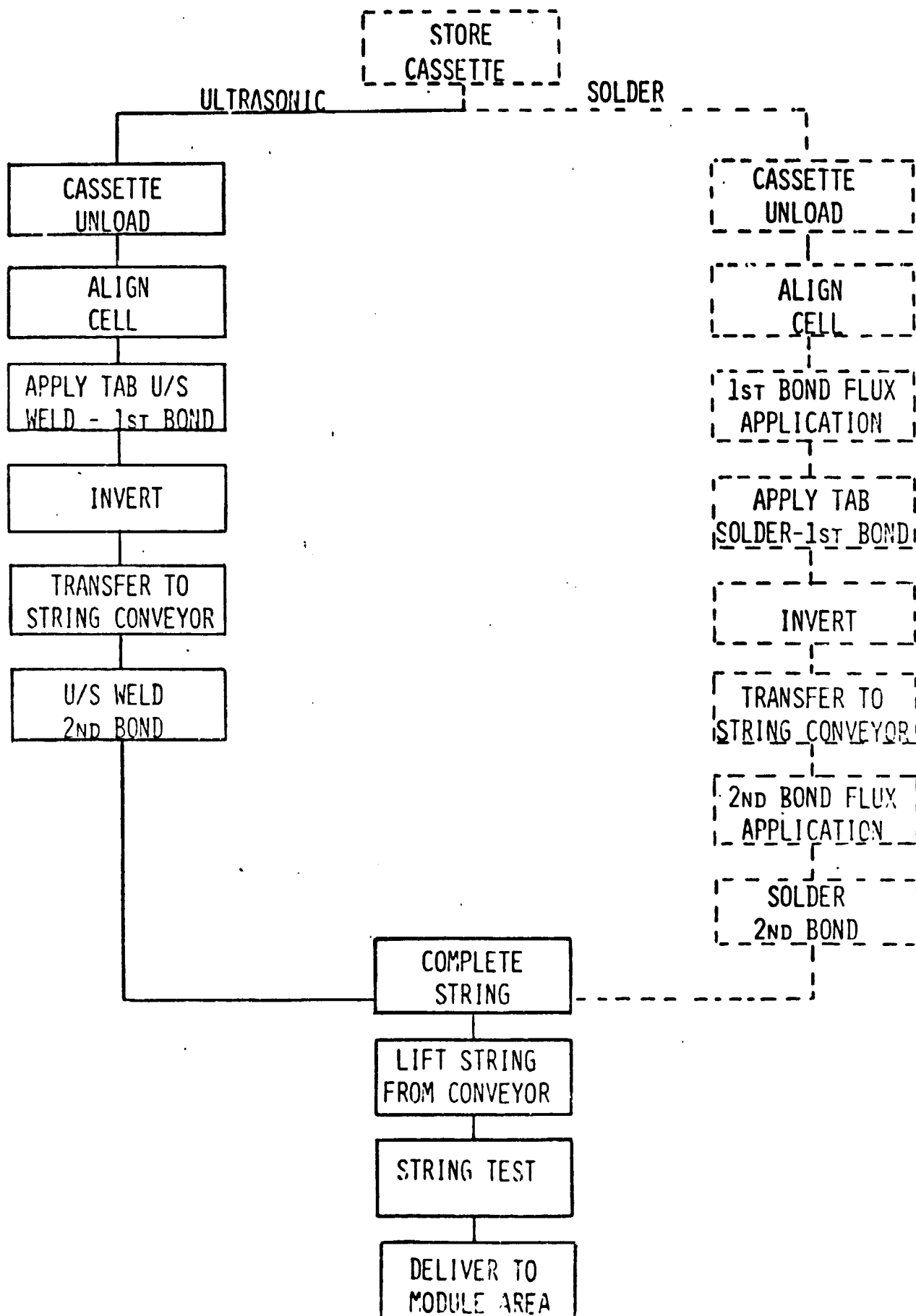


Figure 8. Block Diagram of Proposed Machine Design

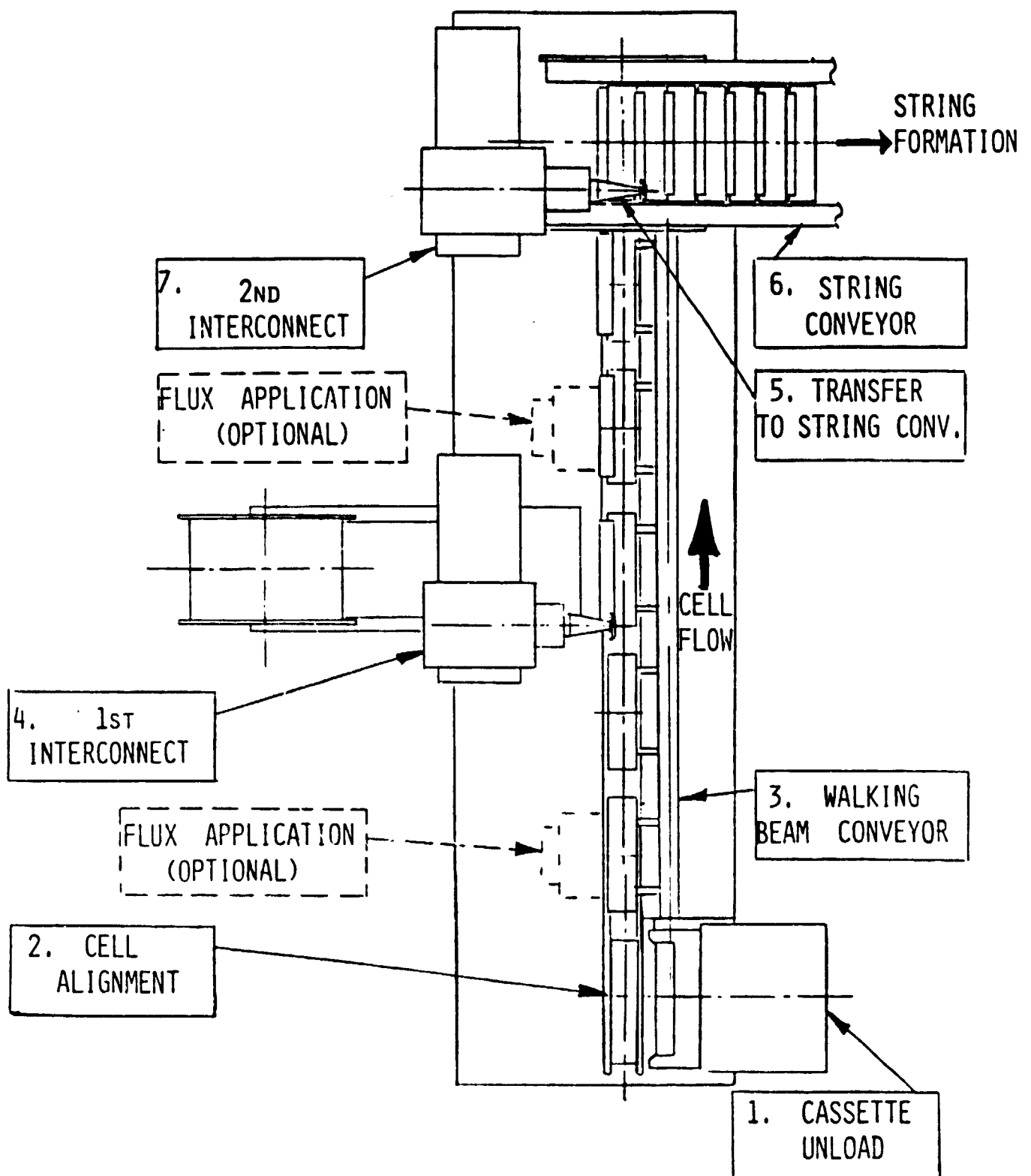


Figure 9. Proposed Machine Design - Cassette Station to String Conveyor

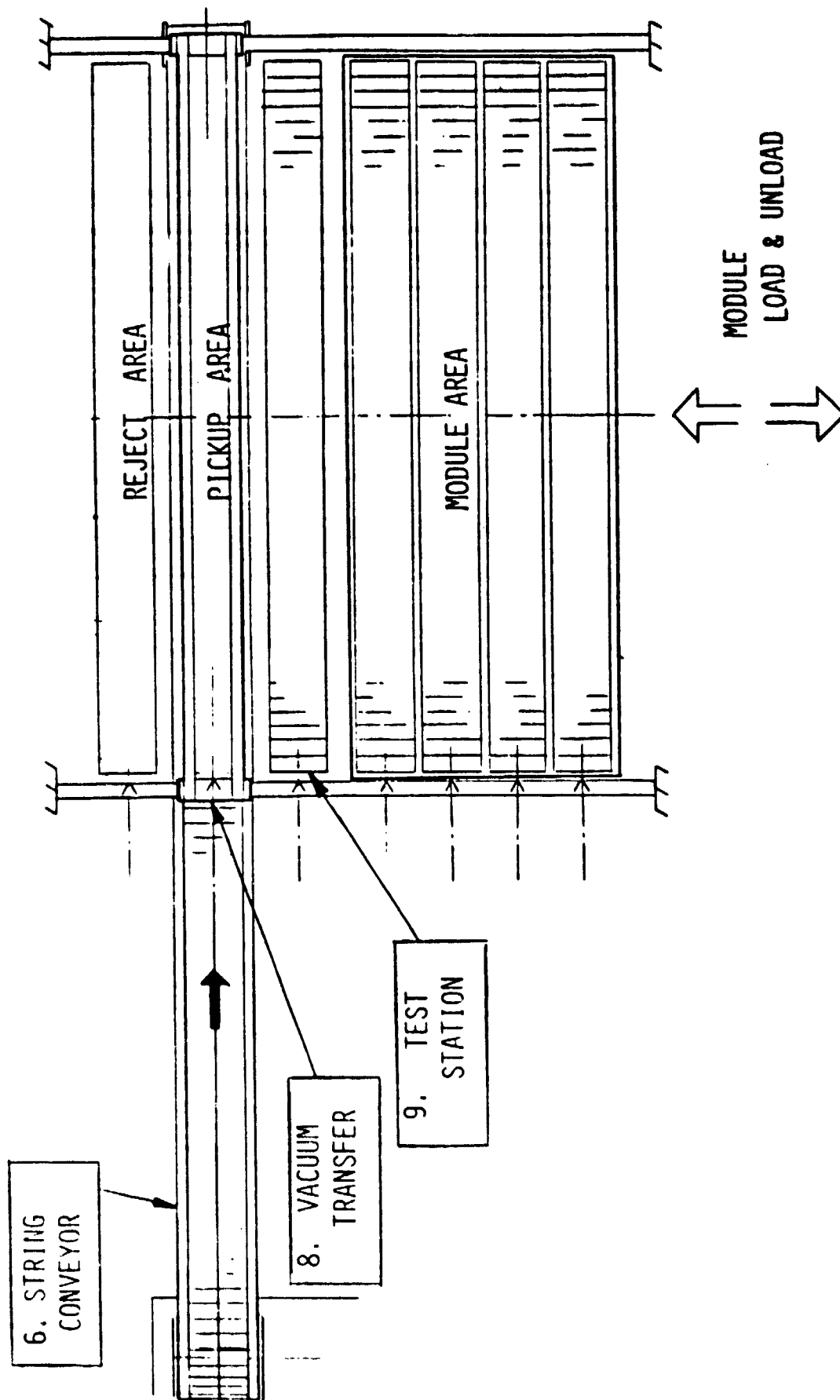


Figure 10. Proposed Machine Design - Module Assembly Area

G. Documentation

(1) Quality Assurance Plan

A preliminary Quality Assurance Plan has been prepared for the MEPSDU Program. This plan delineates the basic Quality Assurance policies and requirements that will be applicable to areas such as design control, procurement control, inspection, test, and process controls, etc. The plan also includes a manufacturing flow chart which incorporates inspection points for receiving, in-process and final inspections, along with a brief narrative description of each inspection or test.

Along with the Quality Assurance Plan, an outline of the contents of a Quality Inspection Procedure that will be developed to perform final workmanship inspection of MEPSDU modules has been prepared. This Quality Inspection Procedure will meet the intent and requirements of JPL Document 5101-21 Rev. B, "Acceptance/Rejection Criteria for JPL/LSA Modules." Both the Quality Assurance Plan and the Quality Inspection Procedure outline were included in the Preliminary Design Review Package submitted to JPL.

(2) Module Engineering and Manufacturing Documentation

The Module Engineering and Manufacturing Documentation consists of all MEPSDU module drawings and a module manufacturing flow chart. The flow chart details the preparation of the layup of ethylene vinyl acetate, Craneglas, Korad, and solar cell subassemblies on a tempered float glass superstrate; the lamination of this layup, the feedthrough of electrical conductors to an external housing; the incorporation of the assembly into a frame; and the inspection and testing of the MEPSDU modules prior to crating.

This document has been submitted to JPL as a part of the Preliminary Design Review Package.

(3) Programmatic Documentation Submittal Status

All programmatic documentation specified in the Westinghouse MEPSDU contract has been submitted in accordance with scheduler requirements. A list of the Programmatic Documentation and submittal dates are compiled in Table 4.

(4) Activities Planned for Next Quarterly Reporting Period

The second quarter of the Westinghouse MEPSDU program covers the period March 1 through May 31, 1981. The first significant milestone of this quarter is the Preliminary Design Review, scheduled for March 4 and 5 at JPL. The design review will focus on the MEPSDU module design, the Preliminary Process Sequence, the Automated Cell Interconnect Station, and the Quality Assurance Program.

Subsequent engineering work in March will be directed toward resolving areas of concern identified at the Preliminary Design Review by JPL personnel. In addition, generation of equipment specifications and vendor contacts will be continued for all MEPSDU work stations.

SAMICS costing work will be initiated. It is anticipated that our first computer run will be made in April.

Work on the Kulicke and Soffa subcontract will continue on machine concepts, and layouts will proceed on individual stations. Work in control system area will focus on determination of the components to be utilized to control automated functions of the machine. Hardware and software requirements of the machine to be developed and built will proceed, as well as decisions made on procurement of specialized items to be used, depending upon lead times for these components.

TABLE 4

PROGRAMMATIC DOCUMENTATION SUBMITTAL STATUS

<u>ITEM</u>	<u>SUBMITTAL DATE(S)</u>
1. BASELINE COST ESTIMATE	DECEMBER 17, 1980
2. SCHEDULE ACCOMPLISHMENT REPORT	DECEMBER 17, 1980 JANUARY 14, 1981 FEBRUARY 16, 1981
3. PROGRAM PLAN AND WBS	DECEMBER 17, 1980
4. TECHNICAL PROGRESS REPORT	JANUARY 15, 1981 FEBRUARY 15, 1981
5. FINANCIAL REPORT	DECEMBER 15, 1980 JANUARY 14, 1981 FEBRUARY 16, 1981
6. DESIGN REVIEW PACKAGE	FEBRUARY 19, 1981